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# SALINITY INFLUENCE ON GERMINATION OF FOUR IMPORTANT MANGROVE SPECIES OF THE SUNDARBANS, BANGLADESH

## SUMMARY

Salinity is an important factor of mangrove establishment, growth and development. Present study was conducted to evaluate the influence of salinity on seed germination of *Heritiera fomes* Buch.-Ham., *Xylocarpus mekongensis* Pierre, *Xylocarpus granatum* K.D. Koenig and *Amoora cucullata* Roxb from the Sundarbans, Bangladesh. This experiment was conducted with different salinity levels (0 to 40 ppt at 5 ppt interval) with Completely Randomized Design for 10 weeks. Moreover, influence of seed dipping at different salinity levels (0 to 40 ppt at 5 ppt interval) on germination was also examined in a Randomized Block Design. Significantly ($p < 0.05$) higher germination was observed at non saline to less saline (5 ppt) conditions for all the studied species. Seed germination of all the species was found to decrease at higher saline levels. About 57% and 21% of seeds of *X. mekongensis* and *X. granatum* were germinated respectively at 40 ppt salinity. While, germination of *H. fomes* and *A. cucullata* was ceased at salinity level of 35 ppt and 20 ppt respectively. The seeds of *X. mekongensis* found to viable even dipping for longer time with higher salinity level compared to other species. In the extreme situation, seed germination of *H. fomes*, *X. mekongensis* and *X. granatum* was ceased at 10 ppt salinity and no germination was observed for *A. cucullatta* after dipping of 4 weeks. In conclusion, seed germination and seed viability found to vary with the species, salinity and dipping duration.

**Keywords:** *Amoora cucullata*, *Heritiera fomes*, Salinity, Sundarbans, X*ylocarpus granatum*, *Xylocarpus mekongensis*

## INTRODUCTION

Mangroves are characterized by evergreen woody plant species with some physiological and structural adaptations to a habitat influenced by saline and tidal inundation in the tropical and subtropical sheltered coastline (Saenger *et al*., 1983; FAO, 1994; Field, 1995). They can tolerate saline and to some extent of waterlogged condition and play a vital role in supporting coastal food webs and

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nutrient cycles in the adjacent coastal ecosystems (Alongi, *et al.*, 2000; Machiwa and Hallberg, 2002; Mumby *et al.,* 2004; Mahmood *et al.,* 2008). Mangroves distribution in the world and their floral diversity are believed to be influenced by temperature, rainfall, wind, tidal inundation, wave action, geomorphology, soil types, soil aeration, nutrients availability and salinity (Spalding *et al.,* 1997).

Species composition and vegetation dynamics of the Sundarbans mangrove forest of Bangladesh are heterogeneous that seems to be controlled by hydrology, tidal inundation and salinity. The hydrodynamics of the Sundarbans is quite complex and it is dominated by the freshwater flows from the Ganga, Brahmaputra and Meghna rivers. The freshwater flows from the rivers and the tidal ingress result in a gradient of salinity that varies both spatially and temporally (Pethick, 2011). *Heritiera fomes, Excoecaria agallocha*, *Xylocarpus mekongensis*, *X. granatum*, *Sonneratia apetala*, *Avicennia* spp. are the dominant tree species of this forest (Hoque and Datta, 2005; Iftekhar and Saenger, 2008). *Heritiera fomes* and *Amoora cucullata* are found at the less saline areas while, *Ceriops decandra*, *Avicennia spp*., *Sonneratia spp*. *Rhizophora spp*., *X. mekongensis*, *X. granatum* and *Bruguiera spp*. are found at the moderate to high saline areas of the Sundarbans **(**Karim, 1994; Hoque *et al.,* 2006; Giri *et al.,* 2007**).** It is reported that *H. fomes* dominated areas are replaced by *H. fomes -E. agallocha* and *H. fomes - X. mekongensis -B. gymnorrhiza* community. The overall shift is from *H. fomes* to *E. agallocha* and from *E. agallocha* to other more saline tolerant species **(**Das & Siddiqi 1985, Latif 2010).

This changes in species composition and vegetation pattern may be due to the changed scenario of salinity regime and tidal inundation (Mahmood et al. 1998, Hoque et al. 2006, Iftekhar & Saenger 2008). Salinity is one of the major parameters that influence the physiological parameters, productivity, growth, survival and regeneration of mangrove plants. Moreover, salinity is also a critical factor for the viability of mangrove seeds and propagules. Most of the mangrove species shed their fruits during the rainy season to increase the chances of survival at lower saline condition of the ecosystem (Bunt et al. 1982). The influence of salinity on seed germination, seedling growth and development of different species of the Sundarbans are not well known. On the contrary, global climate change, specifically changes in temperature, $CO_2$ concentration, precipitation, intensive cyclonic storms and sea level rise, combined with anthropogenic threats will threaten the resilience of mangroves (McLeod & Salm 2000, Agrawala et al. 2003). It is reported that 25 cm increase in the sea level will inundate about 40 percent of the Sundarbans (World Bank 2000). So, sea level rise and lower flow of fresh water from upstream will lead to increase the salinity of the Sundarbans areas (Hoque et al. 2006). This combined effect may exert negative impact on seed germination, seed viability of different important species, which can be appeared as a threat on biodiversity of this pristine ecosystem (Gopal & Chouhan 2006) The knowledge on species specific range of salt tolerance will help to understand the changing pattern of vegetation dynamics of the Sundarbans. Different studies of salinity effect on germination were conducted at different mangroves areas of the world e.g. *Aegiceras corniculatum*, *A. marina* from Hong Kong (Ye et al. 2005); *A. schaueriana* and *Laguncularia racemosa* from Southeast Brazil (Cavalcanti et al. 2007); *Ceriops tagal* from India (Patel et al. 2010); *C. roxburghina* from India (Elumalai & Manikandan 2013). But, there are no studies on seed germination and seed viability of the important tree species like *H. fomes, X. mekongensis, X. granatum* and *A. cucullata* of the Sundarbans and somewhere else. Therefore, present study aims to examine the effect of salinity on seed germination and seed viability of *H. fomes, X. mekongensis, X. granatum* and *A. cucullata* of the Sundarbans, Bangladesh.

## MATERIAL AND METHODS

### Seed collection

The mature seeds of *H. fomes*, *X. mekongensis*, and *A. cucullata* were collected during the month of July 2011 and seeds of *X. granatum* were collected during the month of March 2012 from the Sundarbans mangrove forest of Bangladesh. The mature seeds of these species are buoyant and dispersed through water of cannels and rivers. Nets of 2 mm mesh were used to catch the floating seeds on the water course. Healthy seeds were sorted manually considering the visual appearance.

### Seed germination

The effect of salinity on the germination of *H. fomes*, *X. mekongensis*, *X. granatum* and *A. cucullata* was studied under different saline conditions. In sea water and thus in mangrove environment NaCl represents the highest proportion of salts and others are present only in trace amount. In this study salt means NaCl and hydroponic method was followed for this germination study at the nursery of Forestry and Wood Technology Discipline, Khulna University. Nine treatments of salinity from 0 to 40 ppt at 5 ppt interval were applied in Completely Randomized Design. Each treatment was replicated three times with 30 seeds. Seeds were sown in plastic bowl with coarse sand layer of 2.5 cm. Salt solution of respective treatment was addes to the bowl in such way that a thin layer of solution can be seen on the layer of coarse sand. Frequently the solution layer and their salinity level were cheeked and maintained. Total number of germinated seeds were counted and recorded on daily basis for 10 weeks.

### Seed viability

The effect of dipping of seeds in saline conditions was also tested. The collected seeds of individual species were dipped in nine treatments of salinity from 0 to 40 ppt at 5 ppt interval for 1 to 4 weeks with Randomized Block Design. Each treatment was replicated three times. Thirty seeds of individual species from each treatment were collected weekly for 4 weeks and sown in plastic bowl with 2.5 cm thick layer of coarse sand at non saline condition. Total number of germinated seeds were counted and recorded on daily basis for 10 weeks.

**Statistical analysis**

The germination percentages of seeds of the individual species at different salinity were calculated and transform to arcsine for statistical analysis. The seed germination of different species at different salinity treatments were compared by two-way analysis of variance followed by Duncan Multiple Range Test. Similarly, seed germination of different species at different dipping duration along with the salinity treatments were calculated and transform to arcsine. These germination values were compared by two-way analysis of variance followed by Duncan Multiple Range Test using SAS statistical software.

## RESULTS AND DISCUSSION

Different levels of salinity showed significant ($p<0.05$) influence on seed germination and the germination values found to vary among the species (Table 1 and 2). Significantly ($p<0.05$) higher germination was observed at non saline to less saline (5 ppt) conditions for all the studied species. Among the species, *A. cucullatta* showed highest germination (85%) followed by *X. mekongensis* at non saline condition. The germination of the studied species was found to decrease at higher saline conditions. *Xylocarpus mekongensis* and *X. granatum* appeared as more salt tolerant at the germination stage. About 57% and 21% of germination was observed for *X. mekongensis* and *X. granatum* respectively at highest salinity of 40 ppt. While, *A. cucullata* and *H. fomes* appeared as less salt tolerant and their germination was ceased at salinity of 20 ppt and 35 ppt respectively (Fig. 1).

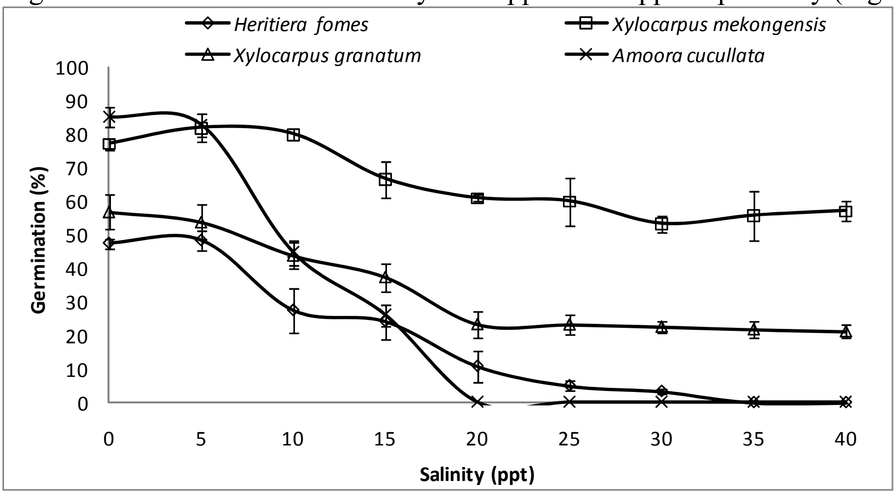



Fig. 1. Seed germination (%) of *Heritiera fomes*, *Xylocarpus mekongensis*, *Xylocarpus granatum* and *Amoora cucullata*

Salinity treatments along with dipping duration have shown significant ($p<0.05$) influence on seed germination of the studied species (Table 1 and 2). Comparatively ($p<0.05$) higher proportion of seed viability was observed for *X. mekongensis* compared to other species.

Table 1: Result of ANOVA for salinity and dipping duration at individual species

| Source of variation | *H. fomes* | *X.mekongensis* | *X.granatum* | *A. cucullata* |
|---|---|---|---|---|
| Salinity treatment | 44.24 | 5.12 | 15.07 | 383.42 |
| Dipping duration with salinity treatment | | | | |
| 1st week | 103.75 | 6.19 | 72.99 | 126.86 |
| 2nd week | 107.01 | 24.30 | 64.22 | 155.94 |
| 3rd week | 48.21 | 61.39 | 133.17 | 54.19 |
| 4th week | | 69.53 | 122.38 | N/A |

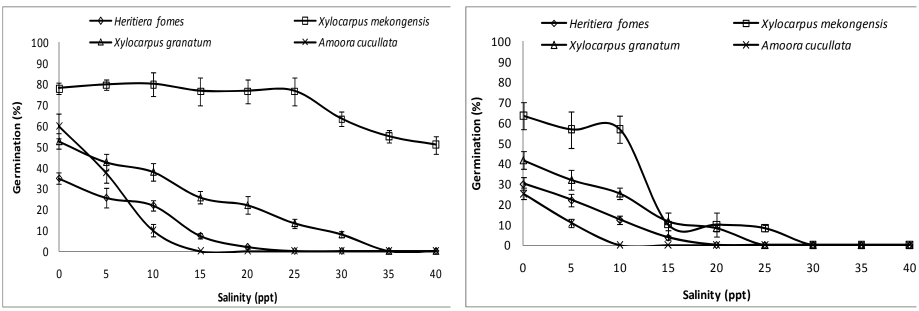
Salinity df = 8, and given F-values are significant ($p < 0.05$)

Table 2: ANOVA result for salinity and dipping duration among the species

| Source of variation | Species |
|---|---|
| Salinity treatment | 66.80 |
| Dipping duration with salinity treatment | |
| 1st week | 192.29 |
| 2nd week | 23.41 |
| 3rd week | 15.27 |
| 4th week | 7.70 |

Species df = 3, salinity df =8, and given F-values are significant ($p < 0.05$)

However, after 1 week of dipping, about 51% seeds of *X. mekongensis* were germinated at 40 ppt salinity. While, germination of *H. fomes, X. granatum* and *A. cucullata* was ceased at 25 ppt, 35 ppt and 15 ppt respectively. Similarly, seed germination of *H. fomes*, *X. mekongensis* and *X. granatum* found to cease at salinity of 10 ppt and no germination was observed for *A. cucullatta* after 4 weeks of dipping period (Fig. 2).




a b

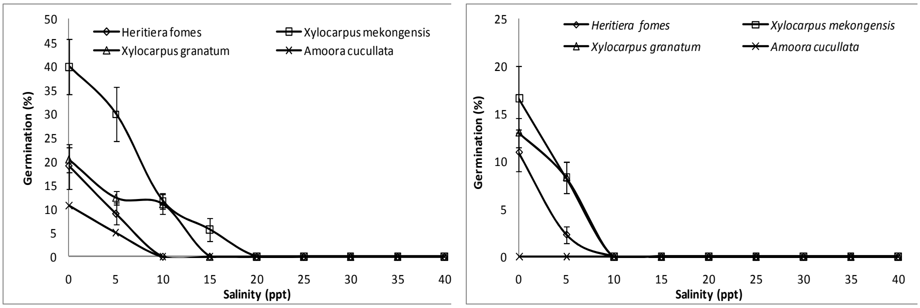



Fig. 2. Seed germination (%) of *Heritiera fomes*, *Xylocarpus mekongensis*, *Xylocarpus granatum* and *Amoora cucullata* with salinity treatments and dipping duration (a) 1 week (b) 2 week (c) 3 week and (d) 4 week

## DISCUSSION

The germination and seed viability of the studied species were significantly ($p<0.05$) varied with species, salinity level and dipping duration (Table 1 and 2). Seed germination is a critical stage of plant's life cycle and salinity can adversely delay and can reduce the germination (Villagra 1997). Mangrove plants are well adapted to salinity for their germination, establishment, growth and development (Tomlinson 1986). But, they are also sensitive to higher salinity during the process of seed germination (Ungar 1996, Khan & Abdullah 2003, Debez et al. 2004). Seed viability and germination of mangrove species may depend on the critical level of salinity which is species and site specific (Yokoishi & Tanimoto 1994, Rubio Casal et al. 2003, Ye et al. 2005, Liu et al. 2006, Cavalcanti et al. 2007). *Heritiera fomes* and *A. cucullata* found to occur at the less saline areas and; *X. mekongensis* and *X. granatum* found to dominate at the moderate to high saline areas of the Sundarbans (Karim 1988, Siddiqi 2001). The dominance characteristics of a mangrove species at a particular site may be related to its salt tolerance at germination stage (Harradine 1982). Lower germination and less viability of *H. fomes* and *A. cucullata* seeds were observed at higher salinity levels compared to other species. This lower germination of *H. fomes* and *A. cucullata* at higher salinity (>15 ppt) may be due to the adverse effect of salinity (NaCl). Similar observation and opinion were also reported by Rehman et al. (1997) with different species of *Acacia*. Increased salinity reduces the germination of both mangrove and glycophyte seeds (Ungar 1982) through slowed down the water uptake by seeds, thereby inhabited their germination and root elongation (Werner & Finkelstein 1995, Begum et al. 2013). Salinity stress affects the seed germination (Sairam & Tyagi 2004) and this adverse effect may be attributed to ionic toxicity and decline in osmotic pressure under the saline condition (Greenway & Munns 1980, Levitt 1980). Internal osmotic and water potential generally increasingly negative with increases in salinity (Khan et al. 1998). Long time dipping in saline condition reduces the seed viability of the studied species may be attributed to negative osmotic potential at higher saline conditions and the toxic effect of NaCl (Bradford 1995, Katembe et al. 1998).

## CONCLUSIONS

The result of this study allowed us to conclude that difference in germination and seed viability are species specific. The salt tolerance of the studied species in terms of germination showed a decreasing trend of *X. mekongensis* > *X. granatum* > *H. fomes* > *A. cucullata*. Therefore, with the increased salinity, less salt tolerant mangrove species of the Sundarbans may be eliminated by the more salt tolerant species and result in change in species composition and loss of biodiversity.

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## UTICAJ SALINITETA NA KLIJANJE ČETIRI ZNAČAJNE VRSTE MANGROVE U SUNDARBANSU, BANGLADEŠ

### SAŽETAK

Salinitet je važan faktor u uspostavljanju, rastu i razvoju mangrove. Ovo ispitivanje je izvršeno sa ciljem da se procijeni uticaj saliniteta na klijanje sjemena Heritiera fomes Buch.-Ham., Xylocarpus mekongensis Pierre, Xylocarpus granatum K.D. Koenig i Amoora cucullata Roxb iz oblasti Sundarbans u Bangladešu. Ovaj ogled je postavljenj sa različitim nivoima saliniteta (0 do 40 ppt u intervalu od 5 ppt) po potpuno slučajnom sistemu tokom perioda od 10 sedmica. Uticaj potapanja sjemena na različitim nivoima saliniteta (0 do 40 ppt u intervalu od 5 ppt) na klijanje ispitivano je i na slučajnom blok sistemu. Značajno ($p < 0.05$) veće klijanje zapaženo je pri neslanim i manje slanim uslovima (5 ppt) kod svih proučavanih vrsta. Klijavost sjemena svih vrsta opadala je pri višim nivoima saliniteta. Oko 57% sjemena X. mekongensis i 21% sjemena X. granatum klijalo je pri salinitetu od 40 ppt, dok je klijanje H. fomes i A. Cucullata prestalo pri nivou saliniteta od 35 ppt, odnosno 20 ppt. Sjeme X. mekongensis se održalo čak i nakon dužeg potapanja u višim nivoima saliniteta u odnosu na ostale vrste. U ekstremnim situacijama, klijanje sjemena H. fomes, X. mekongensis i X. granatum prestalo je pri salinitetu od 10 ppt, dok nikakvo klijanje nije zapaženo kod A. cucullatta nakon potapanja u trajanju od 4 sedmice. Zaključak je da klijavost sjemena i održivost sjemena varira zavisno od vrste, saliniteta i dužine potapanja.

**Ključne riječi**: *Amoora cucullata, Heritiera fomes*, Salinitet, Sundarbans, *Xylocarpus granatum, Xylocarpus mekongensis*